

CLAIMS

What is claimed is:

1. A water-soluble composition for removing petroleum residue from a substrate, said composition comprising:
  - 5 (a) from about 10% to about 60% by weight of an aromatic ester;
  - (b) from about 30% to about 60% by weight of an aliphatic ester;
  - (c) from 0% to about 15% by weight of a co-solvent;
  - (d) from 0% to about 10% by weight of one of a cyclic terpene and a terpenoid;
  - 10 (e) from 0% to about 1% by weight of an odor-masking agent; and
  - (f) from 0% to about 20% by weight of a nonionic surfactant.
2. The composition according to Claim 1, wherein the aromatic ester comprises a benzoic acid ester.  
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3. The composition according to Claim 2, wherein the benzoic acid ester comprises an alkylated benzoic acid ester.
4. The composition according to Claim 3, wherein the alkylated benzoic acid ester is selected from the group consisting of methyl benzoic acid ester, ethyl benzoic acid ester, n-propyl benzoic acid ester, isobutyl benzoic acid ester, n-butyl benzoic acid ester, tert-butyl benzoic acid ester, isomers of pentyl benzoic acid ester, isopropyl benzoic acid ester, and combinations thereof.  
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5. The composition according to Claim 4, wherein the alkylated benzoic acid ester comprises isopropyl benzoic acid ester.  
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6. The composition according to Claim 1, wherein said composition comprises at least about 50% by weight of an aromatic ester.  
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7. The composition according to Claim 1, wherein said composition comprises at least about 40% by weight of an aromatic ester.
8. The composition according to Claim 1, wherein the aliphatic ester comprises a fatty acid alkyl ester.  
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9. The composition according to Claim 8, wherein the fatty acid alkyl ester comprises a fatty acid methyl ester.
10. The composition according to Claim 9, wherein the fatty acid methyl ester comprises biodiesel.  
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11. The composition according to Claim 1, wherein the cyclic terpene comprises d-limonene.  
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12. The composition according to Claim 1, wherein said composition comprises at least about 50% by weight of an aliphatic ester.
13. The composition according to Claim 1, wherein said composition comprises at least about 40% by weight of an aliphatic ester.  
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14. The composition according to Claim 1, wherein the co-solvent comprises a hydrotrope.
15. The composition according to Claim 14, wherein the hydrotrope comprises a diethylene glycol ether.  
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16. The composition according to Claim 15, wherein the diethylene glycol ether comprises butyl carbitol.
17. The composition according to Claim 1, wherein said composition comprises at least about 10% by weight of a co-solvent.  
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18. The composition according to Claim 1, wherein the odor-masking agent comprises a fragrance.

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19. The composition according to Claim 18, wherein the fragrance comprises a lemon tart fragrance.

- 10 20. The composition according to Claim 1, wherein said composition comprises at least about 0.1% by weight of an odor-masking agent.

21. The composition according to Claim 1, wherein the nonionic surfactant comprises an alkoxylated triglyceride.

- 15 22. The composition according to Claim 21, wherein the alkoxylated triglyceride comprises an ethoxyxylated Castor oil.

23. The composition according to Claim 22, wherein the ethoxyxylated Castor oil comprises polyoxyethylene (20) castor oil (ether, ester).

- 20 24. The composition according to Claim 1, wherein the nonionic surfactant comprises an alkoxylated amide.

- 25 25. The composition according to Claim 24, wherein the alkoxylated amide comprises an alkoxylated hydrogenated tallow amide.

26. The composition according to Claim 25, wherein the alkoxylated hydrogenated tallow amide comprises a polyoxyethylene (13) hydrogenated tallowalkylamide.

- 30 27. The composition according to Claim 1, wherein said composition comprises at least about 0.4% of a nonionic surfactant.

28. The composition according to Claim 1, wherein said composition comprises at least about 0.8% of a nonionic surfactant.
- 5 29. The composition according to Claim 1, wherein said composition comprises about 50% by weight of an aromatic ester; about 40% by weight of an aliphatic ester; about 10% by weight of a co-solvent; and about 0.1% by weight of an odor-masking agent.
- 10 30. The composition according to Claim 1, wherein said composition comprises about 40% by weight of an aromatic ester; about 50% by weight of an aliphatic ester; about 10% by weight of a co-solvent; and about 0.1% by weight of an odor-masking agent.
- 15 31. The composition according to Claim 1, wherein said composition comprises about 40% by weight of an aromatic ester; about 50% by weight of an aliphatic ester; about 10% by weight of a co-solvent; about 0.1% by weight of an odor-masking agent; and about 0.4% by weight of a nonionic surfactant.
- 20 32. The composition according to Claim 1, wherein said composition comprises about 40% by weight of an aromatic ester; about 50% by weight of an aliphatic ester; about 10% by weight of a co-solvent; about 0.1% by weight of an odor-masking agent; and about 0.8% by weight of a nonionic surfactant.
- 25 33. A composition according to Claim 1, wherein said composition further comprises water.
- 30 34. A composition according to Claim 1, wherein said composition comprises an aqueous solution.

35. The composition according to Claim 34, wherein said composition comprises at least about a 10% aqueous solution.
- 5           36. The composition according to Claim 34, wherein said composition comprises at least about a 20% aqueous solution.
- 10           37. A composition according to Claim 1, wherein said composition comprises a non-toxic substance.
- 15           38. A composition according to Claim 1, wherein said composition comprises a biodegradable substance.
- 20           39. The composition according to Claim 1, wherein said composition contains no detectable volatile organic compounds (VOC's) according to EPA Method 8260B Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS).
- 25           40. The composition according to Claim 1, wherein said composition has a flash point (closed cup) greater than about 60°C.
- 30           41. The composition according to Claim 1, wherein said composition is essentially free of chlorinated solvents, caustics, or acids.
42. The composition according to Claim 1, wherein said composition has a pH of about 7.
43. The composition according to Claim 1, wherein said composition is as least as efficient as diesel fuel for removing petroleum residue from a substrate.

44. A method for removing petroleum residue from a substrate, said method comprising:
- (a) providing a water-soluble composition, said composition comprising:
- 5 (i) from about 10% to about 60% by weight of an aromatic ester;
- (ii) from about 30% to about 60% by weight of an aliphatic ester;
- (iii) from 0% to about 15% by weight of a co-solvent;
- 10 (iv) from 0% to about 20% by weight of one of a cyclic terpene and a terpenoid;
- (v) from 0% to about 1% by weight of an odor-masking agent; and
- (vi) from 0% to about 20% by weight of a nonionic surfactant; and
- 15 (b) contacting the substrate with said composition such that the petroleum residue separates from the substrate.
45. The method according to Claim 44, wherein the aromatic ester comprises a benzoic acid ester.
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46. The method according to Claim 45, wherein the benzoic acid ester comprises an alkylated benzoic acid ester.
47. The method according to Claim 46, wherein the alkylated benzoic acid ester is selected from the group consisting of methyl benzoic acid ester, ethyl benzoic acid ester, n-propyl benzoic acid ester, isobutyl benzoic acid ester, n-butyl benzoic acid ester, tert-butyl benzoic acid ester, isomers of pentyl benzoic acid ester, isopropyl benzoic acid ester, and combinations thereof.
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48. The method according to Claim 47, wherein the alkylated benzoic acid ester comprises isopropyl benzoic acid ester.
49. The method according to Claim 44, wherein said composition comprises at least about 50% by weight of an aromatic ester.  
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50. The method according to Claim 44, wherein said composition comprises at least about 40% by weight of an aromatic ester.
51. The method according to Claim 44, wherein the aliphatic ester comprises a fatty acid alkyl ester.  
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52. The method according to Claim 51, wherein the fatty acid alkyl ester comprises a fatty acid methyl ester.
53. The method according to Claim 52, wherein the fatty acid methyl ester comprises biodiesel.  
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54. The method according to Claim 44, wherein said composition comprises at least about 50% by weight of an aliphatic ester.  
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55. The method according to Claim 44, wherein said composition comprises at least about 40% by weight of an aliphatic ester.
56. The method according to Claim 44, wherein the co-solvent comprises a hydrotrope.  
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57. The method according to Claim 56, wherein the hydrotrope comprises a diethylene glycol ether.
58. The method according to Claim 57, wherein the diethylene glycol ether comprises butyl carbitol.  
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59. The method according to Claim 44, wherein said composition comprises at least about 10% by weight of a co-solvent.
- 5 60. The method according to Claim 44, wherein the cyclic terpene comprises d-limonene.
61. The method according to Claim 44, wherein the odor-masking agent comprises a fragrance.
- 10 62. The method according to Claim 61, wherein the fragrance comprises a lemon tart fragrance.
63. The method according to Claim 44, wherein said composition comprises at least about 0.01% by weight of an odor-masking agent.
- 15 64. The method according to Claim 44, wherein the nonionic surfactant comprises an alkoxylated triglyceride.
- 20 65. The method according to Claim 64, wherein the alkoxylated triglyceride comprises an ethoxyxylated Castor oil.
66. The method according to Claim 65, wherein the ethoxyxylated Castor oil comprises polyoxyethylene (20) castor oil (ether, ester).
- 25 67. The method according to Claim 44, wherein the nonionic surfactant comprises an alkoxylated amide.
68. The method according to Claim 67, wherein the alkoxylated amide comprises an alkoxylated hydrogenated tallow amide.

69. The method according to Claim 68, wherein the alkoxylated hydrogenated tallow amide comprises a polyoxyethylene (13) hydrogenated tallowalkylamide.
- 5 70. The method according to Claim 44, wherein said composition comprises at least about 0.4% of a nonionic surfactant.
71. The method according to Claim 44, wherein said composition comprises at least about 0.8% of a nonionic surfactant.
- 10 72. The method according to Claim 44, wherein said composition comprises about 50% by weight of an aromatic ester; about 40% by weight of an aliphatic ester; about 10% by weight of a co-solvent; and about 0.1% by weight of an odor-masking agent.
- 15 73. The method according to Claim 44, wherein said composition comprises about 40% by weight of an aromatic ester; about 50% by weight of an aliphatic ester; about 10% by weight of a co-solvent; and about 0.1% by weight of an odor-masking agent.
- 20 74. The method according to Claim 44, wherein said composition comprises about 40% by weight of an aromatic ester; about 50% by weight of an aliphatic ester; about 10% by weight of a co-solvent; about 0.1% by weight of an odor-masking agent; and about 0.4% by weight of a nonionic surfactant.
- 25 75. The method according to Claim 44, wherein said composition comprises about 40% by weight of an aromatic ester; about 50% by weight of an aliphatic ester; about 10% by weight of a co-solvent; about 0.1% by weight of an odor-masking agent; and about 0.8% by weight of a nonionic surfactant.

76. A method according to Claim 44, wherein said composition further comprises water.
77. A method according to Claim 44, wherein said composition comprises an aqueous solution.  
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78. The method according to Claim 77, wherein said composition comprises at least about a 10% aqueous solution.
79. The method according to Claim 77, wherein said composition comprises at least about a 20% aqueous solution.  
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80. A method according to Claim 44, wherein said composition comprises a non-toxic substance.  
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81. A method according to Claim 44, wherein said composition comprises a biodegradable substance.
82. The method according to Claim 44, wherein said composition has a flash point (closed cup) greater than about 60°C.  
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83. The method according to Claim 44, wherein said composition is essentially free of chlorinated solvents, caustics, or acids.
84. The method according to Claim 44, wherein said composition has a pH of about 7.  
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85. The method according to Claim 44, wherein said composition is as least as efficient as diesel fuel for removing petroleum residue from a substrate.  
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86. The method according to Claim 44, wherein said petroleum residue comprises an asphalt residue.
87. The method according to Claim 44, wherein said petroleum residue comprises asphaltene.  
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88. The method according to Claim 44, wherein said petroleum residue comprises bitumen.
89. The method according to Claim 44, wherein said petroleum residue has a boiling point greater than about 150°C.  
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90. The method according to Claim 44, wherein said petroleum residue has a boiling point greater than about 200°C.  
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91. The method according to Claim 44, wherein said petroleum residue has a boiling point greater than about 340°C.
92. The method according to Claim 44, wherein said substrate comprises an equipment article.  
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93. The method according to Claim 92, wherein said equipment article is selected from the group consisting of viscometers, rotational viscometers, penetration testing equipment, dynamic shear rheometers, RTFO equipment, PAV equipment, direct tensile testing equipment, mixers, lab ovens, resilient modulus equipment, SST equipment, Marshall and Hveem flow and stability test equipment, trucks, spreaders and compactors.  
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94. The method according to Claim 44, wherein said substrate comprises a workpiece.  
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95. The method according to Claim 94, wherein said workpiece is selected from the group consisting of utensils, molds, bowls, pans, buckets, shovels and rakes.
- 5 96. The method according to Claim 44, wherein said petroleum residue is one of solubilized, entrained, and suspended in said composition.
- 10 97. The method according to Claim 96, wherein said composition is separated from said petroleum residue by:
  - (a) filtering the composition;
  - (b) pumping the filtered composition into a separation column; and
  - (c) subjecting the filtered composition to a compressed gas.
- 15 98. The method according to Claim 97, wherein the filtering step removes inorganic impurities from said composition.
99. The method according to Claim 97, wherein the separation column comprises a countercurrent separation column.
- 20 100. The method according to Claim 97, wherein the compressed gas comprises one of ammonia and carbon dioxide or a mixture thereof.
- 25 101. The method according to Claim 97, wherein the compressed gas comprises a mixture of ammonia and carbon dioxide at a ratio ranging from about 1:10 to about 10:1 by volume (ammonia:carbon dioxide).
102. The method according to Claim 97, the method further comprising purifying said composition using a spinning band distillation apparatus.

103. The method according to Claim 97, the method further comprising separating said composition from the compressed gas in a depressurization unit.

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104. The method according to Claim 103, the method further comprising releasing the gas from the depressurization unit, wherein said composition remains in the depressurization unit.

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